THE RACCOON: A STUDY IN ANIMAL INTELLIGENCE.

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INTRODUCTION.

The aim of comparative psychology is, in the end, a classification of minds according to the kind and complexity of their thinking. As the criterion for this thinking we are of course confined, in the case of animals, to what they do. We study animal behavior. We can observe what the animal does spontaneously in the wild (or in captivity) and how he reacts in experimental conditions. And nowhere is it more essential that

these two sorts of observation should go hand in hand. No experimenter can feel perfectly sure that his conditions of experimentation are such as to show the animal at his best without a most careful study of what the animal does or does not do in freedom and of its own accord; and no student of animals in the wild can be sure that his interpretation of what he sees is the true one unless the animal can be led to do the same sort of thing under fully known and controlled conditions. As Prof. Jastrow (17) remarks, "we can judge what animals think only by what they do, yet what they really do may be wholly different from what they apparently do."

Trustworthy observations of the life of raccoons in the wild are not easy to obtain, because, perhaps, of their nocturnal habits; and little that is definite and of psychological interest is to be found in literature. Such personal observations as the writer has been able to make upon a dozen or more of these animals in captivity will presently be described. The experimental studies which follow have been for the most part of the general type of those made by Thorndike, Kinnaman, and others, and furnish, it is believed, a tolerable basis for the relative ranking of the raccoon with reference to the animals studied by these experimenters.

It is perhaps fair to state, also, that the present study was begun in the early part of the year 1905, and was complete in its experimental part before the appearance of Prof. Cole's study of the same animal in the May number of the *Journal of Comparative Neurology and Psychology* for the current year. The two papers are nevertheless to a considerable extent supplementary of each other, and an effort has therefore been made to correlate the results and to point out differences.

ZOÖLOGY.

Geographical range and taxonomic relations. The raccoon inhabits the southern parts of the fur-bearing regions. Lewis and Clarke found the animal at the mouth of the Columbia River. The Hudson Bay Company purchased skins as far north as the Red River, latitude 50°. Dixon and Partlock obtained skins from the natives of Cook's River, latitude 60°. On the Atlantic coast, Newfoundland is the northern limit. The animal ranges southward over nearly all of North America and South America as far as Paraguay.

Matthew and Wortman from the latest study of tertiary remains place the immediate ancestor of the raccoon in the Oligocene period, and contrary to common opinion, make its affinity closer for the *Canidæ* than the *Ursidæ*.

Something of its general zoölogical kinship is shown by the

following summary of M. Watson's (37) study of the placentation of the raccoon:

1. *Procyon* agrees with all the other Carnivora in which the organ has hitherto been examined in the possession of a zonary or annular placenta, and also in the mode of interlocking of the fœtal and maternal portions of the placenta, and in the consequent deciduate character of that organ.

2. *Procyon* agrees with all the members of the plantigrade section, at the same time that it differs from those composing both the digitigrade and pinniped sections of the Carnivora, inasmuch as at one spot the placenta presents a gap or deficiency, at which spot the placental structure is imperfect.

3. *Procyon* agrees with *Canis* at the same time that it differs from *Felis* in the absence of a continuous layer of *decidua serotina* from the uterine surface of the detached placenta.

4. *Procyon* differs from every other carnivöre, in the possession of placental vessels possessed of a structure hitherto only met with in the placenta of *Cholæpus Hoffmanni* among the Edentates.

5. *Procyon* differs from every other carnivöre, in the non-possession of an umbilical vesicle.

6. *Procyon* differs from all carnivores of which the young have been hitherto examined, inasmuch as the fœtus is provided with a supernumerary cuticle or epitrichium, a structure which has only been met with in the young of certain members of other mammalian groups.

The length of the period of gestation is not accurately known. Its culmination varies through April and May. The mother gives birth to 4-6, usually in a hollow tree. In the Berlin Thiergarten in the spring of 1871, a mother brought forth five young. The young have been reared in captivity in America in several instances. At birth the young are small, about the size of a half grown rat. It is asserted that they are born blind like some other Carnivora.

General Observations.

In popular opinion, both among the Indians and whites, the raccoon has a high reputation for cunning and adroitness. Reports of the Bureau of American Ethnology (6, 7) have preserved for us many of the Indian folk-stories, in which the raccoon figures either as the chief actor of the story or else the subject of a parallel story in which the doings of some other animal of like cunning have been transferred to it. All these stories from whatever source have but one theme, namely, the subtility and cunning of the animal, which a short acquaintance will render as clearly apparent as it ever could have been to the Aborigines.

Food. Omniverousness has apparently had much to do with the development of the raccoon's hunting habits. He plunders the farmer's cornfield, he lifts the eggs from the woodpecker's nest, he gathers many kinds of nuts, grubs for roots, digs out turtles and frogs, goes berrying in the proper season, robs the chicken roosts, is a good fisherman and clam digger. All these and a hundred other activities combine to show the animal's great adaptability in the securing of a varied dietary. Confinement confirms the characteristics manifested in the wild. The raccoon seldom sulks when the table is spread. He never questions the cooking. He eats a good meal, and, given thirty minutes for refreshment in sleep, is ready for another as bountiful as the first. Fruit, bread, jellies, honey, sweetmeats, fish, molluscs, small crustaceans, rodents, and some green vegetables give sufficient variety for the selection of proper foods for feeding in captivity. Raccoons, however, adapt themselves to some one article of food, and as soon change to any other which may be forthcoming. I have fed them entirely on dog biscuit, then put them on a meat diet, changed to a varied diet, and then returned to the dog biscuit without much apparent loss of appetite, but the animal thrives best on a mixed diet. The particular conditions of feeding during experimentation will be spoken of later. (p.463.)

Physical Characters. The mobility of the fingers, with the sharp and partly retractile claws, which fit the hand for climbing as well as for other purposes; the bushy tail present as a balancing organ, and often slightly prehensile; the broad tuberculate molars, not thin and with cutting edges as in the purely cat tribe; the pointed and double edged canines; are all indicative of the physical resourcefulness of this animal, as well as its ability to hold its own against all comers of equal size. The raccoon climbs the bare steam pipes in the laboratory with as much ease as though they were the trees of the forest. He travels along the electric wire at the ceiling as if it were the branch of a tree and he on the under side of it. The prehensile and balancing characters of the tail appear whenever the animal attempts to climb, or stand on the hind feet in a place where the footing is uncertain, or when it is climbing a vertical surface, in which case the tail is used to steady the body in much the same manner that a woodpecker uses his while chipping the bark of the tree.

Significance of the Name Lotor (The Washer). The nicknames which the raccoon has received are closely associated with his observed habits in the wild. The Indian called him "the scratcher," "the oyster-eater." In Venezuela the Spanish local name is "Fox, wash thy hand." The name "washer" comes from the animal's habit of washing its food. Beckmann

gives an account of one which used to amuse himself by washing various odds and ends in a bucket of water. "An old pot handle, a snail shell, or anything of the sort would do, but the thing he loved the best was an empty bottle. Clasping it in his forepaws he would waddle slowly to the bucket with the bottle clasped close to his breast and then roll it and rinse it in the water. If any one ventured to disturb him, he was furious and threw himself upon his back, clinging so tightly to his beloved bottle that he could be lifted by it." *The Journal of Comparative Neurology*, Dec., 1892, p. 157, cites the case of a tame raccoon which was accustomed to carry his food across his cage to wash it, and if the particles were too small, so that he ate them up on the way to the water pan, he nevertheless continued to wash with nothing in his paws. Later, however, he failed to carry the smaller particles.[1]

The reason for the washing of the food has been variously assigned. By some it is attributed to a lack of saliva. Others say that since the raccoon obtains his food largely from the water, the washing must mean that the animal convinces itself by the washing that it has made a fresh catch. Still others think that the animal washes its food merely to clean or soften it, though the process turns out to be anything but a cleanly one with coons in captivity. Each of these explanations may and probably does have an inkling of the truth, but neither singly nor together, do they make clear the origin or the purpose of this interesting and puzzling, though long observed, habit. If water is not provided, the raccoon takes the food to the dry basin and there repeats his ancestral washing. A basin and water lacking, he sits on his haunches and rubs the food between his dry paws. If the key to the problem lies somewhere back in the long list of ancestral traits we may hope that some animal under observation will yet offer us the proper solution.

Dexterity in the use of paws. The cleverness with which the raccoon uses his paws is seen in the facility with which it will catch insects in their flight, an amusement which appeals to the young ones, and also in the marked ability to pick up minute morsels of food and carry them to its mouth. Ainsworth Davis (11) remarks that, "these peculiar powers of manipulation as regards the organs of prehension, by which the food is seized and carried to the mouth, are indicative of intelligence above the average in the animals in which they manifest themselves."

[1]Audubon remarks that he never saw his tame coon wash its food. In view of this most characteristic habit escaping the notice of the great naturalist, we can but remark, in passing, on the incompleteness of data which any single student may hope to secure from his own observations alone.

This dexterity is, however, in large degree a matter of practice. When raccoons first come in from the wild, and have gotten accustomed to take food from the keeper's hand, the paws are moved simultaneously to secure the morsel. Perfect co-ordination as to direction, in the movements either of both paws, or a single paw, is lacking. Through practice, however, the animals soon acquire the ability to use each fore paw independently, and are finally able to use one paw with greater quickness and accuracy than they formerly used the two. Burk's (8) exposition of the development of hand movements in the child would seem to throw light on this observation, for, as he remarks, "the progress in evolution of hand movements in the biologic scale has been from extreme fewness in number to infinite variety, from simplicity to complexity, from clumsy inaccuracy to precision, from simultaneous associations to those which constitute long series in sequence, from the general to the specialized. Féré shows in one of his works that the ability to move one hand without the other is small among the imbecile class. This tendency of the imbecile class to simultaneous movements suggests atavism since simultaniety is the dominating law of the fundamental movements and succession is the human characteristic of accessory movements. Simultaneous movements of the hand suggests reversion to the conditions when the hand was a fore limb." If, then, these conclusions are true we may here also find some justification for placing the raccoon above the average in the scale of intelligence.

Curiosity. While a perfected hand is without doubt a true index of intelligence, it is at best a physical and indirect one. A much more immediate and essential symptom is the exhibition of lively curiosity—in psychological terms, spontaneous attention and the instinct to investigate. Without it active intelligence is out of the question. The raccoon is an animal which displays this quality in a high degree. Its curiosity contributes to the development of its intelligence while at the same time it often becomes a source of serious lesson teaching. The animal would scarcely fall into the lure of the baited trap unless led on by its curiosity when once the scent of possible food has aroused it. The trapper takes advantage of this when he wraps a piece of tin foil around the trencher of the trap, which is then placed two or three inches under water, where it ripples a little, covering all but the foil with leaves or grass. The glittering foil prompts the coon to investigate.

Sometimes the raccoon manifests a knavery which leads to a just punishment. Groos (16) quotes from Beckmann the following account of a tame raccoon which was especially attached to a badger in the same enclosure. "On hot days the badger was accustomed to take his nap in the open air under the shade of

an alder. Then the mischievous coon found his opportunity, but as he feared the badger's bite he carefully kept his distance, satisfying himself with touching his victim softly in the rear at intervals. This was enough to keep the sleepy fellow awake and reduce him to despair. In vain he snapped at his tormentor; the wary coon trotted to the edge of the enclosure, and scarcely had the badger composed himself before he was at his old tricks. One day he was too severe with the badger, which went off growling and rolled into his hole. After awhile he put his head out on account of the heat and went to sleep thus intrenched. The coon saw that he could not expect much attention from his friend under these circumstances, and was about to set off for home when the badger suddenly awoke and stretched his narrow red mouth wide open. This so surprised our hero that he turned back to examine the rows of white teeth from every point of view. The badger continued immovable in the same position, and this excited the coon's curiosity to the highest pitch. At last he ventured to reach out and tap the badger's nose with his paw. In vain, there was no change. This behavior of his comrade was inexplicable, his impatience increased every moment, he must solve the riddle at any cost. He wandered about for awhile, apparently undecided how best to pursue the investigation, but reaching a decision at last he thrust his pointed snout in the badger's open jaws. The rest is not difficult to imagine. The jaws closed, and the raccoon caught in the trap, squirmed and floundered like a captive rat. After a mighty scuffling and tugging he at length succeeded in tearing his bleeding snout from the cruel teeth of the badger and fled precipitately. The lesson lasted a long time, and after it whenever he went near the badger's kennel he involuntarily put his paw over his nose." The above minutely detailed description shows how dominant the element of curiosity is, and in addition there appears a tenacity of memory plus something almost reflective, which found its expression in a quite fully developed new method of defense, namely, that of placing the paw above the snout when near the enemy. Raccoons, when not too wild, push their paws into all the pockets of the keeper which are accessible, and lift all movable parts of their cage and try to find out what is in or under them. Nothing escapes their notice in the long run. They therefore lend themselves readily to training or experimentation. Details illustrative of this last will follow in a later section.

Vocalizations. An interpretation of the vocalizations of the raccoon is possible only in terms of accompanying circumstance. The cry of the young for the mother is often so nearly like that of the human infant that unless one were accustomed to

hear it, it would easily be so mistaken. A low growl, like that of the bear in quality, warns off the intruder. This is also given when in possession of food and fearing its loss. When the coon springs forward to bite there is the accompanying snarl resembling in pitch and quality that of other members of the dog and bear family. A common call in the woods is in character a purr, which approaches very nearly in quality and carrying powers to the tremulous note of the tree frog. It lacks a little of the shrillness of the frog note, and rises in pitch when uttered by the young instead of the adult. When the mother is nursing her young, she gives forth a note which is almost a perfect imitation of the sound of a humming-bird's wings as it pauses before the flower. The two sounds are so nearly alike in character, that I was myself deceived many times before I was able to locate it in the cage rather than in the vines which grew in the rear. The mother's warning note in danger is almost inaudible. If one attempts to sound the letter *m* short and explosively with closed lips, at the same time allowing the air to be driven in short blasts through the nostrils, a very fair reproduction of the sound results. Although the note is very low, I have never seen a young one fail to recognize it even in the midst of the fiercest tussle of its play. A note quite frequently heard in captivity either while at play or, indeed when angered, can be very nearly reproduced by placing the lips in the position for whistling, and uttering the *oo* of boot followed by *f*—*oof*. This vocalization must also be given explosively. This and the note above require some practice to imitate perfectly. That the vocalizations of the mother possess great significance, although differing but slightly in quality, is shown by the experience with No. 3 when she was captured with her young. The mother was taken from the tree first and placed in a large box. When No. 5 was captured and pushed into the box with his mother he made a vicious attack upon her, but she simply gave out a low purring note and the young fellow immediately snuggled up to his mother and became quiet.

Fear. When the raccoon is afraid, it trembles, crouches into some corner, backs off, and frequently turns and runs. Sometimes the animal stands perfectly still with the head lowered and back hunched, looking at and following every movement in the direction of the cause of fright. The former attitude is shown in the animal at the left in Fi5. 7, Plate II, the latter position is shown in Fig. 4 of the same plate. Often a low vocalization or a diminutive grunt accompanies every movement. Sometimes a coon just in from the wild will try to cover its head and thus, ostrich like, render itself free from all danger. Fright is usually accompanied by a relaxation of the anal and

urinary muscles, resulting in defecation and discharge of urine.

Greed. That the raccoon is greedy goes without saying. An animal whose bare existence usually depends on getting all that can be secured is so instinctively. A raccoon will gather in one place all the food he can secure and sitting down upon it endeavor to keep all others away until the food is completely devoured. The method of dislodgment is to back in, push the would-be glutton from his spoil, and then reaching under the body pull the food to the new possessor. Sometimes there is a direct attack and scuffle. Food is not the only bone of contention. One animal will try to keep the others from the water basin. This activity, however, may change to a species of play. If the food is being given to the whole pack in small pieces, some will take their portion and stuff it in their mouths and return again and again until the mouth is filled to its utmost capacity. Often they will even throw away for the time being what is given them in order to be in the scuffle for the last rations. These activities are simply indications of the adaptation to wild conditions where periods of want follow hard upon those of satiety.

Play. The plays of the raccoon might be classified as: 1. Simple activity; 2. Feeding and fighting plays.

Plays of simple activity are those in which the animal plays for the most part by itself, as when it takes a small stick or wisp of straw, and rubbing it in the direction of its longer axis between the fore paws, raises its paws above its head during the rubbing until finally it falls or rolls over backwards. Catching a dangling rope with the teeth, or seizing a flying trapeze with all four paws and swinging on it, or going through gymnastics on a horizontal bar, also belong in this class. One of the raccoons, after jumping from the roof of the inner cage to a flying trapeze, swung for a few minutes and then fell some three or four feet to the floor of the cage, landing on her back. As if angered by the fall and giving the trapeze the credit for the mishap, she climbed to the top of the inner cage again and attempted to wrench and gnaw it from its fastenings. Here would seem to be the beginning of an association of immediate cause and effect. One of the young coons used to sit at night in front of the swing door to one of the sleeping boxes and raise it up and let it fall for half an hour at a time. I was never able to discover any particular reason for this activity, though there may be an element of pleasure in the rhythmic sound produced. A horse will sometimes move a carriage against its cramped wheel in such a way as to produce a rhythmic sound apparently for that purpose. Sometimes a coon will sit on its haunches and beat a tattoo

with its fore paws on the floor in front, with no other apparent purpose than its own amusement. Tipping over the water basin as soon as it was filled was indulged in by both old and young until I was compelled to put the water in an earthen jar too large and heavy to be tipped over. Catching flies from the walls of the sleeping boxes is a favorite amusement on sultry summer afternoons. Twice I noticed young ones in the act of sucking their paws after the manner of bears.

Among the plays which seem to be related to feeding and fighting, we find the raccoon dipping its paws into the water basin and then thrusting them while still wet into the face of a pursuer; also rubbing the dry and empty paws in the same fashion as when washing food in water, this is often resorted to as a form of amusement during the time between feeding periods. Sometimes one animal will take a piece of food and try to conceal it or run away with it, while others follow and try to secure it. This kind of play takes place when there is plenty of food and all have satisfied their appetite for the time being, since the food itself will often be left for some minutes before being eaten.

The fighting plays appear also in the tussle of the young with each other, old ones among themselves, or the mother with her young. If two animals begin a tussle, they usually stand off facing each other with head down, back humped, and paws extended in front. There are two or three preliminary advances and retreats and then comes the set-to, when, very much as in the "catch-as-catch-can" wrestling, they seize each other with the fore paws and twist and turn in the attempt to throw each other over backwards and thus expose the throat to attack. Once down there will be a playful use of teeth, accompanied by more or less vocalization, followed by a quick break-away and an immediate, or delayed renewal of the tussle. If the young ones begin such play with each other, it often happens that the old ones begin a similar match among themselves. This last may be an instance of imitation, and will receive consideration later. When one of the young ones attempted to hang from a low trapeze and have a good swing, another young one came along and, thrusting his nose into the gymnast's stomach pushed him to the floor and then took the place on the trapeze himself, throwing back his head and playfulty growling at the discomfited fellow who usually took this as a signal to retaliate in a similar attack.

I gave them a rubber ball one day. At first they tried to eat it, but when they discovered that it would roll the play began in earnest. One would back off with the ball between his paws while another would try to secure possession of it. Its

attractiveness lasted but a short time, however, and after the first few days they never played with the ball again.

If the mother and young are approaching each other from opposite directions the mother will sometimes catch the hind foot of the young one just as she is passing and turn it over on its back with a quick flip, the young one then attempts to defend itself with its feet in air, or by curling up against the mother who tries to rub its stomach with her nose. I find this seizing by the hind foot while bearing off with the shoulders to be a very common method of fighting among mature coons. The raccoon also fights on its back, so we probably have here the beginnings of a proper training for future struggles where the life of the animal is at stake. Sometimes the young ones by themselves, but more often the mother would catch one by the tail, or hind foot, either with the paws or teeth, and drag it backwards across the cage. This usually resulted in a tussle, in which the victim on its back tried to seize the head and neck of the attacker with its fore paws and pull it down within reach of its jaws.

The study of Dr. Robinson (30) on ticklishness has evident bearing on this kind of play, and from him I quote:

"Not only every part of our physical frame, but every instinct and appetite, either is, or has been at some past stage of human history, necessary to secure the survival or prosperity of the race. The baring of the teeth, the defensive movements of the limbs; the attempts to protect regions from attack as neck, armpits, and groin are characteristic of tickling pursued to a vigorous outcome. We are dealing with but one type of ticklishuess, viz., that which is especially present in early life—when it is plainly associated with a natural desire or appetite which is intermittent, needing the subject to be in a receptive mood, and which is always associated with laughter and play. This form has a social significance, which the others, as irritability of the mucous membranes, on the palate and in the nostrils, or the palmer surfaces or soles of the feet, have not.

"The more ticklish regions of the body both in man and animals are chiefly the armpits and contiguous parts; the ribs, especially where they join the abdomen; the front and sides of the neck, especially just above the collar-bone; the upper and inner parts of the thigh, over the region known to anatomists as "Scarpa's Triangle"; and on the limbs, the parts behind the knee and in front of the elbow.

"Three points are plain: 1. All the young creatures which obviously take pleasure in being tickled—which have the appetite in a marked degree—are naturally playful, and appear to take a special delight in romps of a rough-and-tumble character, which are essentially mock battles. 2. The regions which are especially ticklish and most carefully defended in these games are those which, in a serious fight with formidable teeth and claws, would prove most vulnerable. 3. All these animals, with the exception of man, are armed in this way, and settle their differences by adroit use of such weapons.

"Hence, a young dog or ape which, in the innumerable sham fights of its youth learns to defend the axillæ where a single bite might sever the axillary artery; the neck with the carotids and windpipe just under the surface; the flanks, and borders of the ribs, where a

comparatively slight tear lays open the abdominal cavity; and the groin where the great femoral vessels lie close to the skin, would, without doubt, be vastly better equipped for the fierce combats for supremacy in after life than an animal which had not undergone the same elaborate training. Warfare becomes more and more a matter of education, tactics, and strategy, and less a matter of brute force, as the scale of intelligence is ascended. Innumerable feints and methods of attack appear which are countered by a series of guards equally elaborate. Strategy depends upon experience, adroitness, and adaptiveness and not upon inherent instincts. It must be learned; and a young animal which had not the advantage of an education derived from sham fights in early youth would be as helpless, when brought face to face with an experienced foe, as one of us who knew nothing of fisticuffs or sword-play would be, if he were pitted against a practiced pugilist or fencer."

One of the most interesting observations upon the play of these animals was made during the first week after I secured the mother and her three young ones. When no one was looking on they used to sally forth from the little inside sleeping boxes into the yard of the large cage. The mother was always leading and each little fellow followed with one of his fore paws on the hip of the fellow just ahead. This seemed like a sort of follow-the-leader game.

In rare instances there appeared activities which might be interpreted as having sexual significance. Such would be those where one animal seized the other by the thighs with the fore paws and held it thus for sometime, or simply dragged it about the cage after having thus seized it.

Hibernation. Attention has already been called to the ability of the raccoon to adapt itself to variations of diet. A study of its life during the first and second winters seems to point to a similar adaptability to prevailing differences of temparature. The characteristics of the hibernating period, as slight beating of the heart, apparent cessation of respiration, loss of fat accumulated during the summer and autumn in supplying the constant demand in the production of heat energy, the necessity of seclusion lest the shock of sudden waking with its heavy demand upon circulation and respiration should cause immediate death; these are all familiar to the student of the habits of mammals undergoing the profound sleep of the hibernating period. The raccoon, however, does not sleep as profoundly as the bear. The constant loss of moisture, compels it to come out of winter quarters and seek the water. In the wild when they come out they sometimes travel for a mile or more, either returning to their own den or turning in with another coon, with which they pass the remainder of the period.

During the first winter my animals went into hibernation in an apparently normal way. They used to come out about once in two weeks for water. At such times they seemed to be get-

ting weaker and weaker. Their actions were those of animals which had been in one position a long time, so that the trembling of the body, and tottering gait might have been due to a cramp from which they had but just found release. On coming out permanently in the spring, one of the animals was taken sick. She lost all her strength. If she attempted to climb or stand up on her hind legs, she would fall to the floor in a helpless condition. The enteric plug of the coon is not as large and hard, proportionately, as that of other hibernating animals, but this animal acted as if poisoned by the retention of the fæces and urine. Proceeding to treatment on the basis of this diagnosis she made a quick recovery after her relief from the disturbing cause.

During the first winter the cage was out of doors. During the second winter, since living in the city rendered it impracticable to keep the cage outside, it was placed in the basement of a stable. This was commodious and well lighted, and without artificial heat. The differences in temperature between inside and outside during the season were of but a few degrees, and yet none of the raccoons went into hibernation. Two others which came in, one about the middle of the winter and another almost at the end, went through the normal process of gradually waking. This failure to hibernate has thus far shown no determinate effect. In fact the physical condition of the animals seems higher since they have been able to avoid the usual depletion of the period. The lower latitudes of the geographical range of the raccoon offer conditions of such a character that hibernation is unnecessary, but the interesting feature of this observation was that so small differences of temperature seem to have been sufficient to cut out the period and habit altogether.

Disposal of excrement. Raccoons in the wild drop the fæces wherever they happen to be and leave them exposed. This is one of the means used by hunters for tracking them or determining their presence in a locality. It is also likely that from the observation of the fæces thus dropped, the Indians acquired sufficient knowledge of their feeding habits to attribute to them the conversations on the effects of certain wild fruits, which we find in the Indian folk-stories.

At first my animals in captivity followed the habit of the woods, exercising no selection of place for the deposit of the fæces. When confined in a small cage of two compartments, an upper and a lower, they soon made a choice, one of a corner in the lower compartment, the other of the entire upper compartment. When put into the larger cage, they gradually formed the habit of depositing behind the inner cage in a narrow but somewhat concealed passageway. When moved into

a still larger cage with other animals, where the floor was covered with sawdust, all soon selected a definite part of the floor and began covering the excrement. The seven animals which are now together in a still larger place of confinement, have two places within the area, and at one of the other of these they all, with but rare exception deposit, urinate, and cover.

Something similar, so far at least, as regards the constant use of a particular place is not infrequently to be observed in the case of other animals. I am not aware, however, that the taking on of the covering habit had been noticed. In any case the observation is a most interesting one. We have a stereotyped form of behavior which, if observed in its final steps alone, would unhesitatingly be pronounced instinctive, actually acquired in a comparatively short time and under observation. That it is a response to some special feature or features of the life in confinement can hardly be doubted, and the question is natural as to how far other stereotyped and seemingly instinctive forms of activity in these and other animals are likewise plastic and owe their seeming fixity to the fixity of the conditions in which the animals usually pass their lives. We may even ask the further question whether man's greater plasticity is not in large measure the reflexion of his complex and varying environment rather than a special endowment.

These questions are of course more difficult to answer than to ask and it is not our purpose here to try to answer them. Even the attempt to fix upon the special features of the life in captivity that are responsible for the change must be largely conjectural. The uniformity of place selected may have an element of imitation in it, to be discussed later, or may be the result of an association by which the odor of the excrement tends, when the time of excretion is near, to suggest the act. The disagreeable association of odure with no possibility of escape for an animal not accustomed to its presence may account for the covering which conceals what cannot be left behind and thus out of sight.

Temperament. Whoever has observed animals, either wild or tame, for any considerable time, sooner or later discovers that they, like the human animal, have widely differing temperaments, and manifest varying characteristics, which may depend in part on physical organization but find proximate cause in changes in weather conditions, food, or other disturbing factors not so readily classified. While it may be less possible even than with man to select distinctive physical marks of temperament, such as the color of the eyes, hair, and skin, temperature, character of the pulse beat and quality of the flesh, yet impetuousness of action, sluggishness, cruelty, ferocity, solitary or gregarious tendencies, moroseness, stupid-

ity, non-irritability, and such like, when observed, go far towards giving a more perfect understanding of animal life. Indeed, these temperamental differences are often as well defined as in the case of human individuals. Some animals are of the nervous, others of the phlegmatic, and still others of the bilious type, if we may be allowed to designate them thus for purposes of description. Those of the most purely nervous type are much more active, make many more movements in experimental work, and yet accomplish the task in the same or less time than their more slowly moving, accurate and phlegmatic fellows.

A blow with a stick may mean to one animal a never-to-be-forgotten injury, while to another it merely serves as a corrective. Raccoon No. 3, whose photograph appears in Figs. 4 and 11, and at the right of Fig. 7 in Plate II, has never ceased to remember a blow which was given in a thoughtless moment, when the master lost his temper. She is always suspicious, and makes use of every opportunity to spring at any person, for all alike are enemies. She will, however, stand up on a box at the opposite side of the room, or even in the middle of the floor and beg for food as if she were the most affectionate of all. (Fig. 11, Pl. II.) Go near and you are met with a growl, a spring and sharp teeth. (Fig. 7, Pl. II at the right.)

Figs. 3, 6, and 10, Pl. II, represent an animal at almost the opposite extreme. She has been punished for wrong doing but never resents it. She will come to you, sit on your knee, climb to your shoulder for food, and if she thrusts her pointed nose into your face, she never offers to bite, snarl, or intentionally scratch you. Fig. 1, is much of this same type, but being blind he must be touched gently, as he can only thus distinguish friend from foe. Fig. 2 shows an animal which was at the first timid and somewhat morose. For more than a year it was impossible to either coax or whip him into obedience; then suddenly, without any apparent cause, he changed entirely. He began to climb into the lap, to eat from the hand, and to do as was desired. He seems still to hold unpleasant memories of a stick which his master seldom carries now, and the passing of the stick may account for the absorption of the field by new and more pleasant associations.

A change of scene seems to affect all alike, save one. It usually takes about three weeks for them to settle comfortably into new quarters, and go about their experimental tasks. When they were moved into the university building I was not prepared to find them refusing to work even at their most familiar tests for more than ten weeks.[1] They even refused to

[1] A series of extraneous disturbances to which they were subjected during the earlier part of their stay in the university building had much to do with their long period of nervousness.

take their food from the hand, save one, as noted above. This is an old coon. Fresh changes may arise but she is never disturbed. She goes about as if all the new were old. I have never been able to get her full history, and so suspect that she may have been in captivity before, and possibly have escaped.

The field of observation in temperamental differences is a large one, but it is fertile with clues to all kinds of experimental problems, and its possible effects have, perhaps, been too little regarded by experimenters generally, especially when experiments have been made upon but few individuals.

EXPERIMENTS.

Animals experimented upon. It is hardly possible to give more than an approximate estimation of the age of the animals which I have had and now have, in view of the fact that they were all secured from the wild and so fully grown as to put accurate figures out of the question. The figures are simply estimates based upon close observation by myself and others acquainted with the life of the raccoon in the wild. They are rough approximations, but are believed to be not far from the truth.

No.	Sex.	Approx. age.	Remarks.
1.	Female.	4½ yrs.	Trapped.
2.	Female.	4½ yrs.	Trapped,
3.	Female,	3 yrs.	Taken from tree with young.
4.	Male.	1½ yrs.	Young of No. 3.
5.	Male.	1½ yrs.	Young of No. 3. Died Feb., 1907.
6.	Male.	1½ yrs.	Young of No. 3.
7.	Female.	Age unknown, old.	Bought. Perhaps previously in captivity.
8.	Male.	2 yrs.	Obtained from Penn. Escaped, recap.
9.	Male.	2 yrs.	Obtained from Penn. Escaped.
10.	Male.	2 yrs.	Obtained from Penn. Escaped.
11.	Male.	3 yrs.	Trapped, escaped, recaptured, died.
12.	Female.	2½ yrs.	Trapped, died.

The ages given are either for the summer of 1907, or the age at death or escape. I have had to do with about equal numbers of each sex, and have not been able to determine that sex makes much difference in the matter of intelligence; it is rather the individual temperament and character which count.

Housing. During the three years which have thus far been given to a continuous observation of these animals, their quarters have been changed and enlarged as numbers increased and experimental conditions made greater demands for space. In the beginning, the first two animals were kept in an enclosure of chicken wire fastened to a wooden framework 6 ft. x 4 ft.

x 6 ft. The wire was reenforced by interwoven iron wire of No. 18 gauge. Inside this enclosure was a small two-storied closed cage in which the animals passed the nights and also hibernated during the first winter. In the spring the third animal which was trapped, No. 11 in the above list, escaped from this cage and thus made necessary the construction of larger and more secure housing. A cage 7 ft. square was constructed, with a wooden framework, which supported heavy iron screens of 1½ inch diagonal mesh, such as is commonly used in banking houses. The rear of this cage was shut in by a series of four two-storied sleeping boxes, so arranged as to be occupied singly or all thrown into communication. This offered facilities for the isolation of any particular animal during experimental periods, and at the same time made it possible to gratify the animals' propensity to crawl in and out through dark and light places. The third move was into an enclosure inside the University buildings. This is 14 ft. square, constructed on two sides of sheathing to a height of 7 ft., the remaining space above being shut in by heavy poultry wire of ½ inch mesh. The inside walls of the building form the other two sides of the enclosure. Two large windows look out on the street, which, however, is some distance away. The wire and the boxes and stands placed on the floor provide opportunity for exercise in climbing about.

Feeding. The sorts of food upon which the raccoon will thrive have already been mentioned (p. 450). In the matter of feeding three meals a day and regularity has been the rule. Bostock's (4) six days' feeding and one day's fasting has also been adopted. This equalizes somewhat the great differences between the conditions of food getting in the wild and in captivity. In so far as possible the times of experimentation have coincided with the feeding periods. In experiments like those in color discrimination, where variation in natural illumination was necessary, there was a departure from this rule. The ration has been fairly uniform. Neither a condition of satiety nor hunger has been sought, but such as seemed on close observation to be that of highest efficiency. It is somewhat significant that, after a period of work, the coons usually retired to the sleeping boxes and took a nap of greater or less duration. Whether this was an alternation of sleeping and eating or one of work and sleep is not clear. Probably all three factors entered in some degree.

Apparatus. In the experiments to be described, the food was placed inside a wooden box 15″ x 11″ x 12″, in the front of which was a door 6″ x 5″, which the animal was required to open in order to secure the food. (See Plate II, Fig. 5.) The

door was adjusted to open outward when it was once released by the locking device. The simple devices used were:

1. *A button.* This was so placed and adjusted that it must be thrust downward through an angle of about 40°. The button was placed at the upper right hand corner of the door during one series of trials, and at the upper left hand corner during a second series.

2. *A vertical gate hook.* This was placed at the middle of the door. It was adjusted to move to the right in one series of trials, and to the left in another series.

3. *A bolt.* This was of the common slide-bolt pattern. It was placed at the left of the door, and adjusted to slide to the left.

5. *A T-latch.* This was placed vertically at the middle of the door and adjusted to move to the right in one series of trials, and to the left in another series.

6. *A lift-latch.* This was placed at the right of the door, and adjusted to be moved through an angle of 90° in order to release the door.

7. *A plug.* This was placed on the top of the box, and so connected with a bolt inside the box that pulling the plug drew up the bolt and so released the door.

8. *A horizontal hook.* This was placed at the left of the door and had to be lifted in order to release the door. It was the same hook that had been used in the vertical position.

9. *A bear-down lever.* This was placed at the right end of the box, and adjusted to fasten the door on the inside. Lifting the inner end about an inch released the door.

10. *A push bar.* This was placed at the right end of the box. It was adjusted to fasten the door on the inside. A thrust of about three-quarters of an inch released the door.

Beside these simple locking devices, which were used singly, the door for certain experiments was held by two or three of such simple fastenings. These will be referred to as *Groups.* The elements of the groups were familiar to the animals from their use singly, and could, of course, be operated in any order. The groups were constituted as follows:

11. *Group I consisted of two buttons,* one at the upper right hand corner of the door and one at the upper left hand corner.

12. *Group II was the same as Group I with the vertical gate hook added* at the middle of the door between the buttons.

The *Combinations,* like the groups, were built up from the simple locking devices already familiar, but they differed from the groups in requiring that the elements should be operated, if at all, in a definite order.

13. *Combination I consisted of four locks,* a bear-down lever at the right end; a plug at the top; a button at the left of the door; and a vertical hook placed a little to the right of the middle of the door. The entire mechanism was so constructed that each simple lock, while a part of the combination, yet fastened the door by itself. The outside and inside views of this combination are given in Figs. 5 and 8, Plate II. When the lever numbered 1 was properly worked it fastened itself so that it could not be moved back again and refasten the door, and at the same time made it possible to pull up the plug 2. When the plug had been pulled, the button 3 could be turned; and

when the button had been turned, the hook 4 could be released, and the door would fly open.

14. *Combination II consisted also of four elements:* a push-bar at the left end; a bolt at the left of the door, to be thrust to the left; a button at the right of the door, to be thrust downward; and a kind of hook, known at the hardware dealers as an inside-blind catch, placed at the top of the door, to be thrust to the right. The internal character of the mechanism was similar to that of Combination I. In this combination, as in the other, the elements were so arranged as to prevent the accidental relocking of any one of them after it had been operated in its proper turn.

All the simple locking devices were set to move at between 300 grms. and 400 grms. It was not possible to adjust them accurately in the case of the combinations, on account of the combined lever system and the crudeness of the construction. In the combinations, therefore, there was much variation in the amount of force necessary to move the fastenings.

Method of Work. Food was placed inside the box, the door closed and fastened by whatever device was in use at the time. The closed box was then placed in the cage and the animal turned loose to investigate. No other incentive was given than curiosity and moderate appetite, possibly intensified by the smell of the food concealed in the box. At the first the box was not fastened to the floor, but it soon became necessary to fasten it, because of the rough handling it received unless so secured.

The times required for the working of the fastenings were taken with a stop-watch reading to fifths of seconds, but the curves presently to be considered were all plotted from the nearest readings in seconds. The time taken, included the entire period during which the animal was in contact with the locking device. If his attention was distracted note was taken of the same, and such and all known sources of error eliminated from the learning curves.

Each animal was given forty trials on each locking device. These forty trials were not always consecutive, because the animal often left the box after ten or twenty trials. Sometimes this was due to a satiety of food; at others it was due to lack of interest. A period of several hours or even an entire day might thus intervene at times between two consecutive trials.

The successful operation of the mechanism in one second was taken as the standard for perfection in the case of the simple locks. In the case of the combinations, the animal was considered up to standard when it worked the apparatus ten times in succession without error in the order or failure in muscular adjustment to the different locking devices. The times of such standard performances was uniformly about five seconds.

Results of Experiments.

Variations in the attack on locks. The tests indicate that each animal shows some individuality in the method of opening the locks, though different methods are employed at different times. Sometimes the variation appears in the way in which the animal approaches the box, and this often involved a characteristic method of attack; again in the order of working a group; and often in bringing into action not only the fore feet, but hind feet, nose and even the weight of the body. Age also makes a difference. Old coons work with reserve, directness, and accuracy; while the young ones, if they work at all, make a much larger but less regulated output of their energy. A few illustrations will make this matter clear.

When the button at the upper right hand corner of the door was first given to No. 1, she used to reach down the front of the box while standing on the top and thrust the button with the left paw. After a few trials she changed. Going around back of the box to the right end and reaching around the corner, she pulled the button towards her with the left paw. Sometimes she would come to the front of the box and thrust the button with the right paw, or with the teeth. Nos. 2, 3, 4 and 5 always went to the front of the box. No. 2 used her nose. No. 3 used her right paw and standing at the left thrust the button from her. No. 4 and No. 5 used both paws, and often teeth and paws.

In the case of the bolt at the left of the door, No. 1 has always worked it from the top of the box, by reaching down the front and thrusting the bolt to the left with the right paw. This method may have been borrowed from the position first assumed in the case of the button. No. 2 stands in front and a little to the right of the door and thrusts the bolt to the left with the left paw. No 3 stands at the left end of the box and pulls the bolt towards her with the right paw. Nos. 4 and 5 adopt at different times the method of No. 2 or that of No. 3. They have never worked from the top of the box thus far.

All five with practical uniformity now repeat the position and method finally fixed upon, whenever the same device is presented, even after intervening periods of days, weeks, or months. When Group II was given to No. 1, she used at the first to open the button at the left by standing at the left end of the box and pulling the button towards her with the right paw; then she would walk round behind the box to the right end and reaching the hook with her left paw pull both hook and button towards her. One variation of this method was to stand in front of the door and thrust the button on the left with the left paw, and the hook and button on the right with the nose. An-

other variation was, standing in front and placing the right paw on the right button, the left paw on the left button, and the nose on the hook, to open all at once. She had made use of the two paw method in the case of Group I, so that it was but a slight addition to use the nose on the hook. The reason for the use of the nose on the hook came from an earlier experience with it when it was the only lock in use. In attempting to open the door on the twenty-fourth trial of the vertical hook series, this animal caught one of her toes between the door and the hook. From that time she adopted the nose method and after more than a year, with no intervening trial she still persisted in it. This seems like in character to the action of the coon with the badger as related by Groos, and both show, in contrast to the repetition necessary to perfect the procedure in such things as opening the locks, that certain elements of behavior, probably those that are supported by strong instinctive tendencies, may be determined once for all by a single experience. The same thing appears also in No. 3's continued resentment of the blow already referred to. (p. 461.)

One of the most interesting and illuminating observations which I have been able to make as to the method by which complicated procedures are perfected is the following: One of the young coons, No. 5, was at work on the beardown lever at the right end of the box. It had just been preceded by the bolt at the left of the door. Although the bolt had been removed, leaving the front of the box smooth, No. 5 still devoted his attention to the place where the bolt had previously been, and nearly wore himself out trying to push something from the place where nothing was present. The previous association was too strong to be easily replaced. In the midst of his endeavors, during which he literally rolled over and over in front of the box, he assumed the position of standing on his head. While working in this position his right hind foot slipped off the top right hand corner of the box, and striking the lever pressed it down and opened the box. From the fourth to the eighth trials he would assume the up-side-down position, and work at the door until his foot slipped off the corner of the box, depressed the lever and so opened the door. His attention, however, was never shifted from the front of the box. Finally, in the midst of his gymnastics, his foot slipped off as usual, but did not strike the bar heavily enough to depress it and open the door, although it remained in contact with it. Distracted by this, he turned and using his fore paws thrust the lever down and opened the door. The next day he was working the lock by slipping his foot from the top of the box to the bar, and then turning about and using his fore paws. On the twenty-eigth trial of the series, he went directly to the bar and

opened the door by thrusting it down, but he still sat down on his haunches, placed his hind foot on the lever, and then assisted with the fore paws. It is fair to assume that in course of time something more easy than this awkward performance would have taken its place,—probably in the end the depressing of the lever with both fore paws, or even the right one alone; but the final steps in the short circuiting were cut off by No. 5's untimely death.

The above seems like a case of a stimulus having to beat out its path over an unblazed trail in a nerve wilderness. It is typical, however, of much of the learning of animals and indeed in a measure of all learning where the way is not opened up by hereditary predisposition or expert instruction. Repetition of imperfectly adapted movements brings about a final happy accident. Many rehearsals of the activities leading up to this follow. Continued practice, in ways not altogether clear as yet, leads to the gradual elimination of the extra movements; the unessential parts of the process are sloughed away and the essential solidified. The steps by which perfection is reached are very short and blindly taken, the new habit arising by slight successive modifications of one already in existence. Perception of the essential relations, if present at all, is dull and stupid to the last degree.

Restated from the beginning, it would seem that the smell of the food, intensified by the complex mental activity of curiosity, in some manner lets loose a surplus discharge of motor activity. This sooner or later leads by accident to an agreeable result and a consequent emphasis upon the nervous tract then in action. In this particular case that underlying the association between the position with the hind foot on the lever and the opening of the door. When this position alone happens to be insufficient the fore paws are brought to assist as the readiest means for that purpose—the members most responsive to any need of that character. So far our raccoon had gone.[1]

Burk (8) enumerates the "chief accessory lines of development that distinguish human movements as such, as: "(1) the breaking up of old bilateral and simultaneous tendencies, characteristic of central movements; (2) the growth of independent movements of smaller parts that previously only moved in conjunction with larger wholes; (3) the co-ordination of various series to form long and complex sequences as we finally find them illustrated by writing, sewing, piano-playing, etc.; (4) the development of precision and accuracy; and finally (5) the response of different movements to a great variety of dif-

[1] On this general matter see the paper of Dr. Meltzer, No. 22 of the bibliography at the end of this paper.

ferent stimuli." These all seem to find a ready illustration in the development of animal activity as well as in the child, although in the former case they may be placed on a somewhat lower level.

No. 1's experience with Combinations I and II, furnishes material of similar significance. As before stated, the locks of the combinations were not uniformly adjusted as to the force necessary to operate them (p. 465). Reference to Table I, shows the two chief sources of error, and the average number of errors per trial, in groups of ten. Thus 4.6 is the average number of errors in order, made in the first ten trials on Combination I, and 8.5 is the average number of errors of force applied in the first ten trials on Combination I. Lines 3 and 4 give similar results for Combination I, after a period of 286 days, with no intervening trial. Lines 5 and 6 give results for Combination II, as lines 1 and 2 give them for Combination I. The table seems to show that the memory of the order is more readily perfected, than that of the muscular adjustment required for each particular locking device. It would seem as though the order was something that could become definitely fixed while the muscular adjustment could proceed only to the point of pulling till something gave way. The reduction of errors in order is, perhaps, more uniform and less erratic, than that of errors of applied force.

TABLE I.

Relative proportions of errors in order and errors in force in working the combination locks.

Combination 1.	1	Errors in order.	4.6	8.0	9.3	8.4	7.6	8.4	1.1	2.1	1.8	0.7	0.0	0.0	0.0
	2	Errors in appl'd force.	8.5	10.4	11.1	8.8	10.4	10.3	5.6	5.9	3.4	0.9	0.0	0.0	0.0
Combination 1 after 286 ds.	3	Errors in order.	3.5	0.7	1.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	Errors in appl'd force.	10.5	0.7	3.4	0.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combination 2.	5	Errors in order.	18.6	7.2	2.8	5.5	4.5	4.5	3.0	2.8	0.5	0.0	0.0	0.2	0.0
	6	Errors in appl'd force.	24.1	24.2	7.3	7.3	4.6	5.0	3.0	2.8	1.7	0.0	0.4	0.5	0.0

It is highly significant that the order was a constant quantity throughout the entire series of trials with each combination, while the force necessary to move any individual part of the combination was never quite the same. Proper co-ordination and development of precision and accuracy finally appear,

however, so that once the proper conditions are given, for the starting of a series of movements, they then follow with due force as well as in proper sequence.

In this connection No. 1's method of working the plug is also interesting. When the plug was first given, the method was to stand on the top of the box and pull out the plug with the teeth. The paws were often used to assist while in this position. After the first ten trials, she discovered that she could stand in front of the box and reach up and pull the plug out with her teeth. A few more trials changed the method to standing in front of the box and reaching up behind the plug and jerking it out with the left paw. After this final method became settled, the animal used to come to the front of the box sit up and place her paw behind the plug, look around in a seemingly careless fashion and jerk the plug out without giving any special attention to the process. It was almost as if she would think the device too easy to need anything more than a passing notice. Some such explanation may be plausible for different characters present in the learning curves, yet to be considered.

Cole (10) found with his raccoons, contrary to Thorndike's experience with the cats, that the animals never began work at parts of the box where fastenings had previously been, but went at once to the place of the fastening then in use. The raccoons "did not paw at the place where the loop had been nor did they claw at the loop or button when the door was open. I tried moving the loop from place to place in the boxes. Not once even did they claw where it had been; instead they attacked it at the new place with one direct movement." The trials of my coon No. 5 with the bear-down lever, during which he worked with so much energy at the place where the bolt had been, as described above, point in exactly the opposite way and lead me to think that Cole's results must be exceptional.

My No. 3, an old coon, the mother of No. 5, also behaved in a way to lead to a similar conclusion. After she had pushed back the vertical hook and the door had sprung open, she used to sit in front of the box, pull on the hook and then look inside to see if there was any more food. It was rather humorous to see her repeat this performance again and again. Later she dropped it and has never shown a like tendency since. Whether she gave evidence here of a perception of simple relations, as "this hook gives food," which later changed to "this hook and hole do not give food," may be open to question. When, however, the door was fastened and food placed inside, she never refused to work this lock. The above does not seem to differ much from the habits of the wild. The ani-

mal certainly senses certain conditions as indicative of food, and certain other as indicative of no food. The resulting associations persist and strengthen themselves in the first case. The latter cease to stimulate.

Old coons soon discover the difference in pulling at the long or the short arm of a lever, as in the button, while the young coon will work indifferently on the long or the short arm just as it happens to attack the device. It seems, sometimes, as if there were a kind of intelligent husbanding of energy, which shows itself with age. The tremendous output of energy in youth may be necessary to proper growth and the acquisition of experience, and possibly its numerous errors are thus intimately connected with the learning process.

In the working of Combination I, Raccoon No. 1 reached the arbitrary standard of ten perfect performances in trials ninety-eight to one hundred and seven. In the case of Combination II, the standard was reached in trials one hundred and twenty-five to one hundred and thirty-four. Since the first learning of the order, some variation has occurred in the animal's working of the locks in Combination I, all, however, in the direction of economy. The bear-down lever is now often opened by stepping on it with the hind foot as the animal mounts to the top of the box for the plug, and the button and hook on the front are usually opened by one movement of the right paw. This activity is similar in character to that of No. 5 already described on p. 467. No. 1 is shown in the act of doing this very thing in Fig. 9, Plate II. The tendency to "short circuit" is clear again in this instance.

In the tests with the combination locks an opportunity occurred for noticing the persistence of certain impressions and the signal importance of making no false steps in training. In the first fifteen trials on Combination I, the number of errors was comparatively few. During the next three trials, it was discovered, that while the combination was a perfect working mechanism if worked forward, an accidental reversal of the first element, the bear-down lever, would lock the box again. The animal did this very thing once, and after the device had been so arranged as to make its repetition impossible, more than fifty trials were necessary to bring the errors down again to the level of the first fifteen trials. "Fogging" an animal in this manner while under training will obviously play havoc with figures and render the results difficult of interpretation. Combination II had as one of its elements what is known at the hardware dealers as an inside-blind catch, with which the raccoon had had no previous experience. It proved, however, no more difficult than other parts of the combination. The animal seems to have attained to a sort of generalized behavior

with regard to fastenings which made small differences of little consequence.

After the two combinations had been learned perfectly, the raccoon would work them indifferently. If she were given one or two trials on Combination I and then it was replaced by Combination II, the animal never made the mistake of beginning on either apparatus as if it were the other. In view of the fact that the two combination boxes were not exactly of the same dimensions, and differed somewhat in color, there is little doubt that this difference sufficed to touch off in each case through the association centres the proper order and relation of movements for the particular combination presented.

The animal tends strongly to approach the boxes from one direction only. If this avenue of approach is blocked up, a new adjustment to the new condition will, of course, take place, but the old fastening from a new side presents about the same difficulty as a new fastening.

Time Required For Working the Several Devices.

The figures in Table II are typical of results obtained by this method of work with Raccoon No. 1. The figures are the times in seconds for the forty trials on each of thirteen simple locking devices and the two Groups. Similar tables for the other animals have been prepared but as they would present no significant variations other than those that will be mentioned as the exposition proceeds, it has been thought best not to publish them. The locks in the case of this animal were learned in the order here given.

The large figure 1's mark the record of the trial in which the animal worked the lock in one second for the first time. The medium figure 1's mark the record of the first trial in which the standard of one second was permanently reached.

The Learning Curves. In order to give a graphic representation of the nature of the learning process, as shown in the animal's experience with the locks, the following method was adopted, for which the writer is indebted to the kindly assistance of Prof. W. E. Story, of the Mathematical Department of Clark University. First, all trials affected by known sources of error were eliminated from each series. Then, since the working of the lock in one second had been determined upon as the standard of perfection, the number of trials necessary to attain this standard permanently was determined. Each series naturally gave a different number. Reference to Table II, for instance, shows that in the series for the bolt the standard was reached on the seventeenth trial, while in the case of the horizontal hook, the standard was reached on the fourth trial. The times of the trials were then plotted as

TABLE II.

Time required for working the several devices in the case of Raccoon No. 1.

Trials.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Butt. R.	180	81	316	144	179	18	16	32	8	6	14	6	11	74	2	3	3	2	4	4	60	30	6	7	3	2	**1**	1	65	15	**1**	1	1	1	1	1	1	1	1	1
Butt. L.	24	46	40	9	2	35	14	16	6	34	2	21	6	4	3	2	9	**1**	4	9	4	6	10	4	6	11	9	6	1	5	3	2	4	6	2	**1**	1	1	1	1
V.Hook.	47	90	10	32	4	2	**1**	3	4	4	4	40	2	1	4	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bolt.	190	60	10	**1**	4	5	10	1	3	4	8	5	2	1	1	2	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T-Latch L.	25	3	**1**	5	10	12	2	3	5	14	15	5	5	2	1	1	4	1	1	1	1	1	2	1	13	1	1	1	12	1	6	1	1	4	**1**	1	1	1	1	1
T-Latch R.	35	15	11	50	6	5	**1**	4	1	3	3	1	2	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L't-Latch.	**1**	1	12	8	2	1	7	1	1	1	1	1	1	1	1	1	5	7	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
H.Hook.	5	**1**	5	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lever.	72	30	2	**1**	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	2	1	2	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1
Plug.	30	7	3	3	2	**1**	2	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P'sh.Bar.	264	234	40	15	6	17	**1**	11	1	1	9	2	3	1	3	3	3	3	1	1	2	1	2	1	1	2	1	1	2	**1**	1	1	1	1	1	1	1	1	1	1
Grp. I.	16	9	9	80	6	14	9	39	8	5	4	3	3	3	20	12	22	8	6	3	2	13	10	**1**	2	3	2	2	**1**	1	1	1	1	1	1	1	1	1	1	1
Grp. II.	20	**1**	2	5	6	2	2	3	2	2	4	9	3	15	1	2	2	2	1	1	1	1	9	1	6	1	1	2	**1**	1	1	1	1	1	1	1	1	1	1	1

ordinates, and the number of trials from the first experience with the lock till the standard was reached as abscissas, as many equidistant points being taken along the horizontal axis as there were trials necessary to reach the standard. Thus in the case of the bolt mentioned above, the whole base line would be divided into sixteen equal intervals, giving with the point of origin seventeen points, while in the case of the horizontal hook, it would be divided into three equal intervals, giving four points. Proceeding in this manner, it was possible to superimpose graphically the curves for all the trials of an animal on all the locks. The average of all the times of the superimposed curves, for any single ordinate, therefore, determined a point in a generalized curve of learning which, as a whole, represents each animal's experience with all the locks. Several of the curves thus obtained are given in Plate I. Figs. 1-5 are the curves respectively of raccoons No. 3, 5, 4, 1, and 2. No explanation has yet been found for the elevations in curve No. 4 at intervals three and six.

The curves, with perhaps the exception of the first, have the usual form of the learning curve. They agree in showing at first a more or less rapid falling off in the time required to work the different devices, followed by a gradually decreasing rate of progress as perfection is neared. The curves, however, fall into three groups of somewhat different types represented by Figs. 1 and 5; 2 and 3; and 4 respectively. Comparing Figs. 2 and 3, with Figs. 1, 4, and 5, it appears that the young animal learns more rapidly at first, having perhaps more to learn than the old, as shown by the sudden and long fall in their curves, Figs. 2 and 3, while the old animal profits more evidently by experience, as shown by the uniformly low level of the curves in Figs, 1, 4 and 5 after about the eighteenth or twentieth interval. The continued unevenness of the curves for the young animals is undoubtedly due to the fact that their learning is accompanied by fumbling and distraction of attention for a long time. The variation between Figs. 2 and 3 may be due to the fact that Fig. 3 represents the trials of an animal that is partially or totally blind, and thus is compelled to rely more definitely on touch and smell, and so loses the directness attendant on sight. Figs. 1 and 5, with their peculiar rise at about the twelfth interval, do not readily lend themselves to interpretation. This is especially true in view of Fig. 7 which represents the combined trials of the above four animals on one locking device. This device was not the first one given, but one chosen after each animal had had some experience with locks. This particular curve represents the tests on the vertical gate hook. It is typical, I think, when all things are taken into consideration. It presents, however, the

PLATE I.

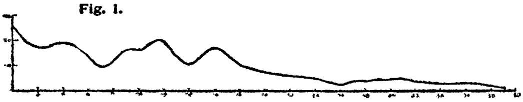

Fig. 1.

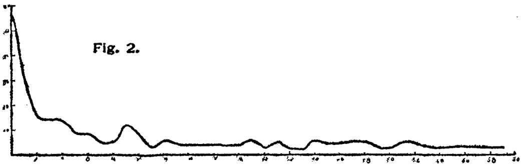

Fig. 2.

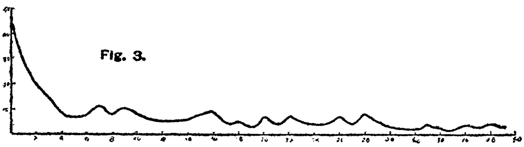

Fig. 3.

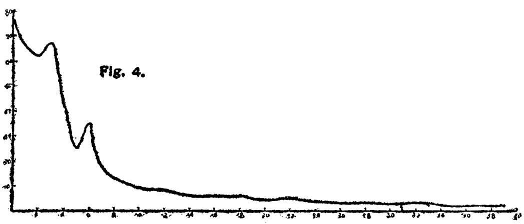

Fig. 4.

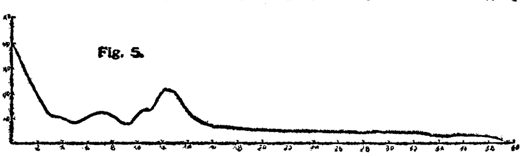

Fig. 5.

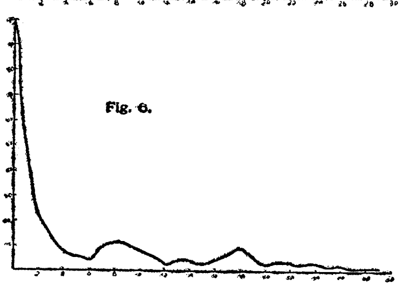

Fig. 6.

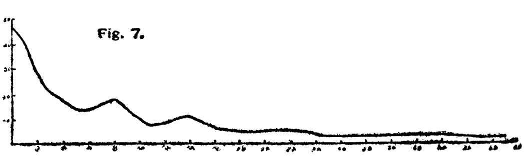

Fig. 7.

above mentioned peculiarities of Figs. 1 and 5, but has the same general character as all the curves. These rises may mean that after the first period of learning there is a short period of forgetting, or of inattention and indifferent effort. Familiarity with a given locking device would in such a case enter as a factor to increase the time. I have already described something of this sort in the trials of No. 1 on the plug (p. 470). We may have here perhaps the analogue of the "plateaus" which have received attention in the learning curves of human subjects. A comparison of Figs. 1, 5, and 4 would seem to indicate that there may be a temperamental factor in these elevations. The animals whose trials are represented by Figs. 1 and 5 are slower in all their activities than the animal whose trials are represented by Fig. 4.

Fig. 6 is interesting by way of comparison. This represents the series of thirty trials each on nine simple locking devices used by Kinnaman in his experiments with the monkeys, which were similar to those used by me with the raccoons under very nearly the same conditions. The figures are taken from his table and plotted on the same plan as the curves already considered for the raccoons. The general character of the curves is evidently the same for both animals. The value of the first experience seems, however, a little more evident in the case of the monkeys as shown by the steep descent of the curve. Indeed, the monkeys would seem to be a little less clever at the start. Elevations like those in Figs. 1 and 5 are to be noticed, but farther apart, falling on intervals eight and eighteen. The irregularity of the curve would suggest that the raccoon is less open to distraction than the monkey; and this might be considered by some as evidence of a lower level of intelligence on the ground that the coon works mechanically, but the opposite position might just as well be taken on the ground that the curve shows greater power of concentrated attention which is evidence of higher intelligence. My own position is one of uncertainty, since I have never had an opportunity to make general observations of the monkey's activities. These differences may also be of a temperamental character. It would seem evident on the face of the curves alone that the two animals stand fairly close together in the matter of learning to undo locking devices.

Combinations I and II were given to boys and girls to learn and the results of the trials were plotted on the same plan as the curves given above. Although the number of trials necessary to attain the standard fell inside of thirty, yet the character of the curve is the same as in the case of the animal.

The curves and the observations which they rest upon seem to justify the following general conclusions:

1. The learning curve for the raccoon follows closely the type of those found for other higher animals and for man.
2. The variations of method which appear in the animal's working of the locks and lead up finally to a permanent method seem to be simply the tendency to the formation of a "short circuit" by the elimination of useless movements, the permanent method being the shortest circuit for the raccoon.
3. There appears to be an increasing husbanding of energy, and profit by experience with increasing age.
4. There is an evident ability to respond to small differences in complex relations. How far the perception of such relations really enters is, however, for the present in doubt.

Experiments upon Association and Memory.

No one who has had to do with animals doubts that they remember, but the question as to the nature of the memorial processes is quite another matter. We have good reason to believe that the life of the animal lies very largely in the field of sense experience and an apparent recognition of relations may in any case prove to be nothing more than a reinstatement of the conditions under which the first association was formed.

During the tests with the raccoons on the simple locks, varying intervals of time broke the series of forty trials for each into groups of a less number. This was necessitated by the failing interest of the animal, but was readily accepted by the experimenter from a desire to discover if there was any well defined recollection from one period to another of the work done. It was soon evident, as had been expected, that the animal carried over from period to period some sort of an association, which resulted in a reduction of the time consumed in the working of the lock. It was then decided to give a crucial test to coon No. 1 using Combination I as the apparatus. The animal had been given preliminary trials with Combination II for a period of nine days, the intervals varying from seventeen to thirty-seven hours.

The results of these trials showed that memory is perfect for such short periods. The tests with Combination I extended over a period of 332 days, and the intervals varied from nine hours to 286 days, the latter period including the time of hibernation. The severity of the test is evident. Where the interval was short the memory was perfect. At the end of the long period there was a repetition of a series of trials similar in character to those made when the box was presented for the first time more than a year before. Only 24 trials were necessary to attain the perfect standard which had previously required 107 trials, and the times of these 24 trials were much shorter than the first 24 trials of the 107 trial series. It is thus

clear that while complex associations lapse somewhat with a long interval in which the original conditions are not present there is yet retained a pretty fair knowledge of what was at first presented. In the case of simple locking devices, however, after an interval of more than a year, with no intervening trial, different animals attack the lock with about the same accuracy, and with no greater variation in the time consumed than would appear in successive trials at the end of an original series in which the time had been reduced to its lowest factor. Simple associations would seem then to be quickly and permanently fixed.

It is extremely easy to underestimate the difference in associative responses that may follow the change in a single element of the situation presented to the animal. Animal No. 6, which manifested such fear and obstinacy when the keeper carried a certain stick, never seems to associate blows from the stick with the keeper himself. Nos. 3 and 8, which are always shut up at night in a small cage by themselves, had to be driven in at the first with blows from a stick. Now the association has been transferred to a mere movement of the box, at which signal they spring to the door and claw it open. No relation exists for them between keeper and box until the box has first been moved from the wall.

A study of the number of errors made in learning Combination I, brought out a tendency which had not shown itself before. If the animal left off a series of trials with a certain number of errors, and the intervening period was short, it would in the majority of cases begin the next series of tests with a *less* number of errors than it was making at the end of the preceding series. Two factors may have contributed to this result: 1. An unconscious elimination of errors during the interval ot no practice; 2. A positive development of the right order, the 1, 2, 3, 4, thrusting itself into the foreground until at last it gained the ascendency.

The raccoon seems to give a high grade of attention to the work in hand. This is of importance in the development of its associations and their permanence. Perfection of the order of manipulation seems to come suddenly at last in spite of what we know from the curves and otherwise of the framework of associations which has been slowly set up in the midst of long continued and apparently aimless fumbling.

Experiments on Color Perception.

There is excellent experimental evidence that monkeys can discriminate colors as such. With raccoons the only experiments as yet reported are those of Cole (10), which he himselt regards as inconclusive upon this point. The experiments

about to be described seem to me to indicate with a good deal of probability that the raccoon cannot discriminate colors as such, but depends on differences in brightness alone. His color blindness will perhaps seem less remarkable when it is recalled that the raccoon is the most nocturnal of all our mammals save the bats and flying squirrels, and that the work of Schultze and Ramon y Cajal has shown the retinas of nocturnal animals in general to be deficient in the retinal cones which seem to be essential for color vision.[1]

Apparatus. 1. A board 1″ x 10″ x 48″, had six holes bored on its centre line, 6″ apart. Six cylindrical tin cans, of uniform height and diameter, 4″ x 2½″, were fitted with plugs on the bottom, made to fit the holes in the base board, and thus prevent their being overturned. These cans were covered with Milton Bradley papers. Four were covered with the standard colors, red, blue, yellow, and green, the other two with neutral gray No. 1, and green gray No. 2.

2. The second piece of apparatus accomplished the same purpose as the first, by the use of six vertical slides, 6″ x 3″, with an opening 2″ x 1½″, cut at a uniform height from the base. These slides could be set in guides, in front of separate compartments 2½″ x 2½″ x 6″. The guides separated the slides about 2″ from each other. One set of slides was covered with the same papers as the cans of the first apparatus. A second set was covered with Hering's graded grays. This apparatus did not allow the animal to look into the container in which the food was placed.

The Milton Bradley papers were tested for brightness in a darkened room on a color mixer, using discs of black velvet and white cardboard as standard black and white. These determinations gave the approximate brightness value of red in terms of the white cardboard as 14°; green gray No. 2, 70°; blue, 82°; neut. gray No. 1, 140°; green, 167.5°; yellow, 240°.

The Hering grays of apparatus No. 2 were matched for brightness with the same apparatus as used above, but in diffused daylight. The black was given an approximate correction by use of Kirschmann's correction factor (*Wundt's Phil. Stud.*, Vol. 5, p. 300). These corrected numbers gave the series of approximate brightness values for the grays as 14.5°, 18°, 70°, 105.5°, 179.3°, and 360° respectively.

Method of Work. The two pieces of apparatus were used indifferently. The food was placed under one color, and when this color was moved to a new position, every other color was given a new position also. All changes in the apparatus were

[1] *Cf.* also Parinaud (27) La sensibilité de l'œil aux couleurs spectrals. The eye of the raccoon also agrees with the results of Slonaker (31) for other mammals below the primates in its lack of a fovea.

made out of sight of the animal. When the apparatus was set, it was so placed as to give the animal about three feet of free space for approach. In this series of tests the trials were made also under widely varying conditions of illumination, viz., morning, afternoon, twilight, cloudy days, and at night by lamp light. The sense of smell was fogged by strong essences, essential oils, and other means used by trappers to disguise the trail.

Results of Experiments in Color Perception.

Of the several thousand tests made on different animals, I have given in Tables III, IV, and V, a series of tests covering color experiments with two animals, and brightness with one, coons Nos. 1 and 2. The results in Tables IV and V were obtained from the same animal, coon No. 2. Each vertical column gives the number of times in thirty trials in which the animal went directly and without hesitation to the color named. For further abbreviation, gray in Table V represents the sum of all the choices of brightnesses other than black. These tables are, I think, characteristic of all results obtained by further tests on the same or different animals. They show nothing more than a qualitative tendency. No tests involving Weber's law have yet been made.

TABLE III.

Food in Green.

Red.	11	7	9	5	7	6	6	3	2	3	7	2	4	9	8	7	2	7
Blue.	3	1	2	6	0	9	4	9	5	10	8	4	5	6	6	3	4	2
Gr. Gray No. 2.	6	2	3	2	1	7	8	4	2	4	4	5	8	5	3	2	2	7
Neut. Gray No. 1.	2	6	7	3	6	4	4	6	5	3	2	6	0	1	2	4	9	4
Yellow.	2	8	7	10	2	0	1	1	8	1	4	5	6	4	5	8	1	3
Green.	6	6	2	4	14	4	7	7	8	9	5	8	7	5	6	6	12	7

TABLE IV.

Food in Red.

Red.	7	9	5	7	12	13	12	7	14	7	7	8	6	13	10	12	19	15
Blue.	2	1	4	4	3	6	2	6	2	2	3	5	8	0	7	6	1	0
Gr. Gray No. 2.	2	5	2	4	0	1	2	4	5	2	1	1	2	5	9	7	1	1
Neut. Gray No. 1.	8	4	4	6	7	6	9	7	0	2	7	9	5	2	2	2	4	6
Yellow.	3	6	7	5	7	2	2	2	7	9	6	4	6	3	1	1	4	3
Green.	8	5	6	4	1	2	3	4	2	8	6	3	3	7	1	2	1	5

TABLE V.

Food in Black.

Black.	11	23	13	22	14	17	20	20	26	29	27	29	28	26	29
Gray.	19	7	17	8	16	13	10	10	4	1	3	1	2	4	1

Where color and brightness enter as simultaneous factors in a series of tests as in Tables III and IV some confusion results. A comparison of the results from all the tests on color and brightness, in percentages (Tables VI and VII), shows a decided variation in favor of brightness. These tables summarize all the color and brightness experiments thus far made. It will be recalled, of course, that in the experiments with the brightness and also with the colors the animal should have chosen rightly by mere chance in about 17% of the trials. That coon No. 2 did better than this is probably due to brightness discrimination.

TABLE VI.

Showing Percentage Choices of Colors.

	No. Tests.	Right Choices.	Upper Limit.	Lower Limit.
Coon No. 1.	960	20.5%	43.3%	7%
Coon No. 2.	1020	40.7%	63.3%	23%
Coon No. 3.	600	16.5%	26%	8%
Coon No. 5.	450	18.4%	30.5%	12.5%

TABLE VII.

Showing Percentage Choices of Brightness.

	No. Tests.	Right Choices.	Upper Limit.	Lower Limit.
Coon No. 1.	690	45.5%	90.3%	16.6%
Coon No. 2.	600	65%	96%	36%
Coon No. 3.	420	59.7%	93.3%	10%
Coon No. 5.	360	39.7%	90%	30%

Profiting by the experience in discrimination of brightness when associated with color, the animals attain as shown in Table VII, a high level of discrimination when brightness alone is present.

Cole's experiments seem to confirm the results here recorded. His black-white tests give values superior to those tabulated by me, he having obtained as high as 100% in a fifty trial series. He displayed his test-colors pairwise, however, thus offering but two possible choices, while in my experiments the number of possible choices was greatly increased in that all six slides were exposed simultaneously. Thus if the tendency to discriminate should appear in the case of the six exposures, it must thrust itself up through a comparatively thick stratum of disturbing elements. In the case of the red-green tests one of Cole's animals made as high as 91½% of right choices, and

another 83⅓%. He found, however, in this case as well as in that of the blue-yellow discrimination, that many more trials were necessary to attain successful discrimination than were necessary for a like discrimination of black-white.

A comparison of the Milton Bradley papers, used by Cole as well as by myself, according to the approximate determination of brightness given on p. 479, shows a brightness difference for blue-yellow, of 158°; red-green, 153.5°; black-white, 345.52°; black-yellow, 225.52°; black-blue, 67.52°; black-green, 153.02°. My own experiments show that in a rough way the raccoon can discriminate a difference of four degrees, and since all Cole's tests save one lie far outside this difference, I feel that his results give stronger confirmation of brightness discrimination than of color discrimination. Undoubtedly the raccoon can be taught to make what seem to be color discriminations, but it will really be a discrimination of brightness difference, which discrimination is essential to his wild life. He hardly needs color discrimination, since in the darkness of the night all colors fade to graded grays.

Imitation.

When we approach the study of imitation in animal life we enter upon a field of controversy and of clashing definitions. It is necessary, therefore, that I state explicitly what I am going to mean by the word in the section that follows. I begin by excluding at the outset, all very accurate and nicely adjusted co-ordinate movements which bear the marks of inherited motor responses. If one of two puppies is thrown into the water and paddles his way to the shore while a second one looks on, we by no means have a case of imitation when the second puppy is likewise thrown in and also paddles ashore. And we can further exclude even those sorts of activity which are dictated by a strong gregarious instinct. We shall not in the present instance regard as imitation such actions as the general flight of a flock of crows when one or two of their number start off in alarm. For present purposes we shall regard as imitative those activities only which are individual in their nature and which are formed on the model of the acts of other animals. The action of the parrot which learns to talk, and the youth who goes to the Klondike in order, like others, to make his fortune, we shall regard as imitative. And we may distinguish two grades, illustrated tolerably by these two examples: a lower grade in which the imitation is executed for the satisfaction which it itself gives, and the other in which the imitation is undertaken with a view to the accomplishment of a definite result. The first of these is of an instinctive type and appears characteristically in many birds besides the par-

rot, in human infants, and possibly in the young of other species. The second is of a rational character, and when present is a mark of considerable psychic development. Here the issue seems fairly joined, for in raising the question—Does the animal on seeing a certain action performed by another desire to do the same in order that a certain result may follow?—we take our stand on the border line, howbeit somewhat broad, which separates rational from merely intelligent thinking,

In interpreting an action as imitative many investigators have placed great stress on what the animal *saw*, at the expense of what the animal *desired*. But even what an animal sees is by no means always certain, quite apart from physical imperfections in vision due to albinism, myopia, or nocturnal habits. Like Jastrow's "really do" and "apparently do," what an animal really sees and what it apparently sees may be widely different. Sufficient data from general observations are not yet forthcoming to certify the usual methods of testing imitation as fairly free from probable sources of error.

Citations will illustrate the point of contention. Berry (2) writes in regard to the rat:

"When put into the box he first tries to get out at the place nearest to the food, but not succeeding there he gradually works away from that spot until he has tried almost every spot in the box, or until he pulls the string that opens the door. Then his attention being attracted to the door by the sound it makes in opening, he runs to it and passes out to the food. When he is put back, take notice of what happens. Does he run at once to the string, pull it and open the door? By no means. He tries the door and finding it closed makes many random movements before starting in the general direction of the string. After nosing about in its vicinity for a time he finally succeeds in finding it and pulling it and thus escapes. It is not until he has got out many times that he goes at once to the string, pulls it and passes out, without making at first a number of random movements."

"These facts in regard to the way the rat learns to get out of a box are of vital importance in helping us to decide what we may reasonably expect from the rat in regard to imitation. If, when a rat by chance pulls the string and hears the door open, passes out and is fed, it cannot go directly to that string when put back, why should we expect a rat that has merely witnessed the performance to be able to do it. The rat that opens the door not only sees the string and sees his paw pull it, but he has in addition all the sensations that are connected with the movement of pulling the string, while the rat that looks on has only the visual sensation, no kinæsthetic sensations. It seems to me that we ought to be able to say *à priori*, in the light of these facts, that no ordinary rat would be able to open a door by pulling a string, simply from having seen another do it, without first making a number of random movements."

It is upon such a slender basis that Mr. Berry infers imitation. He lays great stress on the visual sensation as the chief factor in what he calls the final imitative act. It would seem as though he begs the whole question. If the act was imitation

in any true sense, just what we should expect to see would be the rat pulling the string with much fewer random movements, else in what particular does No. 2's method of learning to get out of the box differ from that employed by No. 1? Indeed, it would seem to require more than the "ordinary rat" to acquire the ability to free itself from the box, if it had no other tutelage than seeing another rat do the same thing. Small (32) expressly states, that he has never seen a case of what might be called inferential imitation. "By this I mean," he says, "merely the learning to do a thing by seeing another do it—the purposive association of another's action with a desired end."

Cole (10) again writes in regard to his raccoons:

"After having had some six weeks of experience in distinguishing a black from a white card and in distinguishing complementary colors, each of the four raccoons developed a tendency to reach over the front board of the apparatus and claw up the colored cards. This tendency was encouraged and finally they would claw up the right (food) card and go to the high box to be fed, or, having clawed up the wrong (no food) card they would claw it down. So far as imitation is in question, the important point is that the raccoons did begin to do, or try to do what they had seen done by the experimenter. Before they began this they had learned to watch the cards and the movements of the trainer's hands very closely indeed. Therefore, the animals either imitated or else from their impatience to see the right card come up there sprang the idea that they themselves might make it come up. This, however, may be all there is in intelligent imitation."

To the present writer it seems that there is yet another alternative in this case. The behavior of the raccoons in clawing up the cards was due either to imitation, or to the idea that they themselves might make the proper card come up, or *it was an accidental result of the raccoons inveterate impulse to attack and manipulate anything that can be moved.* The animals had already associated the colored cards with the getting of food ; had earlier still been accustomed to get food by attacking some sort of fastening ; from this it is a short step—hardly a step at all—to attack the card holders. After having succeeded a few times in thus starting the train that leads to feeding, the activity would become stereotyped like the opening of boxes or any other. In any case we might expect imitation to occur, if at all, more readily when members of their own species furnish the models; and while these cases remain few and uncertain we may well entertain reserve as to those where the coon seems to imitate the experimenter.

As to the imitation of one coon by another, though I have been alert to discover it, I can report only doubtful or negative observations. Coon No. 3 sits up and begs for food (Fig. 11, Pl. II). She took up this activity of her own accord. I have simply strengthened the association of food and sitting up, by refusing food unless she does so. At the first No. 8 used to

sit up also. They took up the attitude together. Soon No. 8 dropped it and then picked it up again about three weeks later. Now he sits up regularly. No. 2 and No. 4 were taught to climb to the top of the stand in the middle of the floor of the cage for their food. No. 4 was taught to stand up on this stand for his food. He is blind so no visual element could have entered into his learning of the trick, but No. 2 which climbs to the stand with him, never stands up for food unless it is held directly above her head, when she will reach for it. No. 2 has had good opportunity to observe and therefore, copy, but no imitation has resulted. It might perhaps be thought that the climbing of the stand was the beginning of the imitative process, but No. 2 has been accustomed to climb to my shoulder for her food for more than a year. Climbing to the stand was therefore, simply a change of place. In the cases of No. 3 and No. 8, the position which they assume is one which is natural to the animal when suddenly startled. It then sits up to look for the cause of the disturbance. The position is also a preliminary fighting attitude. Both animals are timid and have not been long in captivity. It would seem, therefore, that we had here merely a partially transferred association from that of —danger, sit up—to that of—food, sit up.

No. 6 has taken to himself the habit of jumping for his food. This activity has been fostered, until he now jumps about 3 ft. high for his morsels. He is in the midst of the pack when they are being fed. No other animal has yet copied his method, although he rubs against them and jumps from their midst continually.

Six animals escaped from the cage in one night, by pulling down the wire netting in a corner at the ceiling. Three of these belonged to one litter; a mother and her two young were the second three. Once out of the cage, the first three jumped from the window to the ground a distance of some sixty feet. Two escaped, the injured one was recovered. The other group concealed themselves in one of the ventilating shafts in the wall of the building from which they were extricated with difficulty. Three other animals remained in the cage and made no apparent attempt to escape. The case of the six that escaped might be considered as indicating something of imitation, but I think it rather a case of the group or gregarious impulse to which I have already referred as of a different sort from the strict type of imitation under consideration. We know as yet so little of the importance to animals of litter and species odors, and of the general basis of gregariousness, that this factor must not be lost sight of.

Excluding such cases as this last and the doubtful ones of defecation and play already referred to (p. 456 p. 460) above, I

have seen nothing that I thought I was justified in regarding as a clear case of imitation, especially none of the inferential type. At the same time I am far from believing that imitations of the more instinctive type may not yet appear, especially in the case of young animals and of raccoons when free at night.

SUMMARY.

In summing up the results of the observations and experiments reported above the writer feels justified in making the following statements:

1. The common opinion of the adroitness and cunning of the raccoon is well founded and in agreement with his habits in the wild and with what may be inferred from his physical equipment and great adaptability.
2. The raccoon's instinctive powers of attention and curiosity are of a high order as compared with those of other animals.
3. The coons under observation developed a characteristic of depositing their excrement in a fixed place and covering it there, a form of behavior to which they are not accustomed in the wild.
4. The raccoons under observation showed wide differences in temperament—differences which are fundamental in the interpretation of all tests on their intelligence.
5. The experiments in which the animal opened various locking devices in order to obtain food showed a considerable variety of attack in the case of different animals and to a certain extent in the same animal at different stages. The perfecting of the power of undoing fastenings is accomplished by a slow series of small changes, consisting chiefly in the omission of unnecessary movements and the combination of those required.
6. The order of procedure in working the "combination" locks was perfected before the amount of effort necessary was fully learned.
7. Experience with former fastenings holds over in the case of new ones leading the animal at least in certain cases to begin his attack at the place on the surface of the food box where he has been accustomed to work. (This has been found by Thorndike in the case of cats, but denied by Cole in the case of raccoons.)
8. When an animal is forced to approach a familiar fastening from a new direction, it is often about as much bothered by it as by a new fastening. Nevertheless in course of time the animals seem to reach a sort of generalized manner of procedure which enables them to deal more promptly with any new fastening (not too different from others of their experience) than with the first few which they mastered.
9. The old animals seem to learn less rapidly at first than

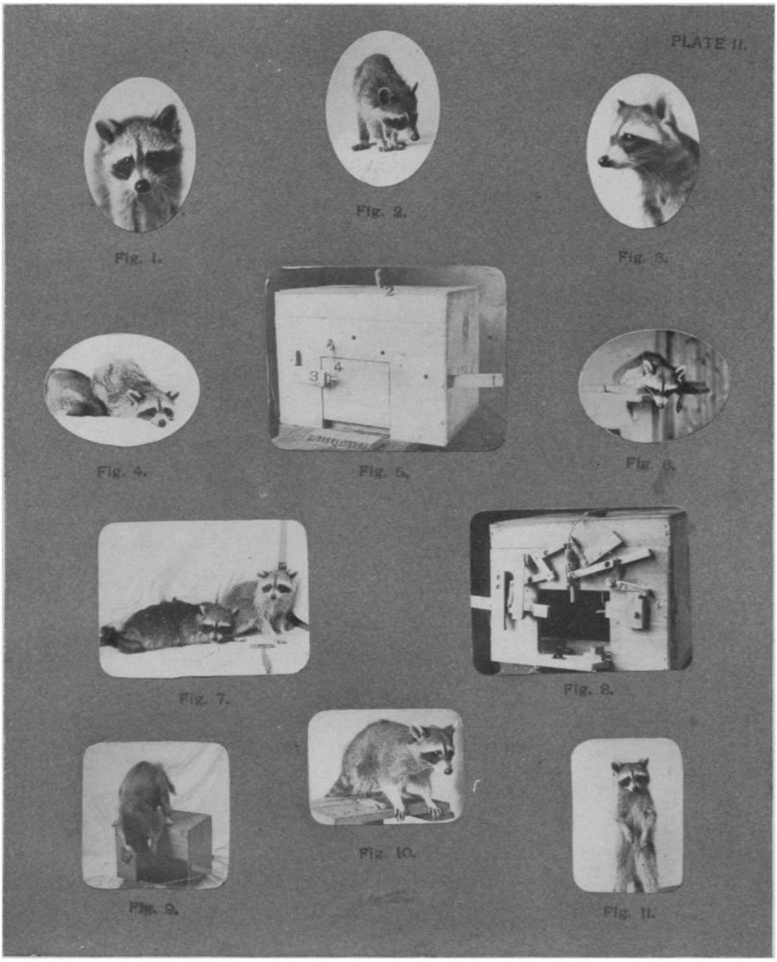

PLATE II.

Figs. 1, 2 and 3 show animals No. 4, 6 and 2, in characteristic attitudes of attention.

Fig. 4. No. 3 in the attitude of fear.

Fig. 5. Combination No. 1 closed and set, ready to be given to the animal.

Fig. 6. No. 2 in a characteristic resting or sleeping attitude.

Fig. 7. No. 8 at the left in the attitude of fear, and No. 2 at the right ready to fight.

Fig. 8. Internal mechanism of Combination No. 1, showing the interplay of locking devices.

Fig 9. No. 1 in the act of opening 3 and 4 in Combination No. 1.

Fig. 10. No. 2 in the attitude of attention.

Fig. 11. No. 3 begging for food.

the young, but profit more by their experience later, possibly because they are more attentive to the matter in hand and are more economical in the matter of effort and movement. These age differences appear in the learning curves.

10. The learning curves for the raccoons and Kinnaman's monkeys, so far as they permit a comparison of the animals, seem to show a nearly equal facility in learning to undo fastenings.

11. Test of the raccoon's powers of retention show that skill in undoing simple fastenings once learned remains practically undiminished for periods of no practice of more than a year. In the case of the "combination" locks the memory was imperfect after a period of 286 days, but the relearning was rapid, only 24 trials being necessary to gain a facility that originally required 107.

12. There was evidence in certain cases, where the intervals of practice were relatively short, of a gain in facility during the period of no practice, so that the animal began with fewer mistakes after the interval than before. This may, however, have been due to the beneficial effect of rest since the animal usually went to sleep at once after the tests.

13. The animals after practice adapt themselves correctly to comparatively small differences in the situation with which they are confronted.

14. The experiments on the discrimination of colors and brightness indicate with extreme probability that the raccoon is color blind. The raccoon's nocturnal manner of life would lead the experimenter to expect this result.

15. No certain cases of imitation of one raccoon by another were observed. The two or three doubtful cases were on the instinctive, not upon the rational level.

I wish here to thank Dr. E. C. Sanford for his kindly encouragement, suggestions and criticism during the entire period of observation. I owe acknowledgment also to Mr. J. H. Starr for assistance in the capture of the animals, and observation of the habits of animals in the wild which were fresh and first hand.

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